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ABSTRACT

This report develops a conceptual framework for considering policy options to improve access to Japanese and other foreign scientific and technical information. The rationales for and against a role for the federal government in accessing foreign technical information are detailed, and the stages in the process of information access are described. Program options for federal government action are presented, the costs of such access-enhancing policy options are considered, and recommendations for Congressional action are made. (EW)

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CRS REPORT FOR CONGRESS

JAPANESE TECHNICAL INFORMATION: OPPORTUNITIES TO IMPROVE U.S. ACCESS

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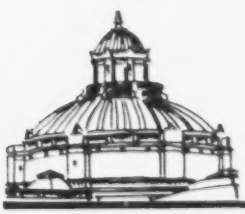

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ABSTRACT

This report develops a conceptual framework within which discussion of policy options to improve access to Japanese and other foreign scientific and technical information might take place. It presents a policy analytic perspective on rationales for and against a Federal role in such access, and it discusses the pros and cons of proposals for a greater Federal role in the future. Legislative proposals to enhance access to foreign technical information are summarized. The report also describes several options for enhancing U.S. access and offers estimates of their costs.

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I. INTRODUCTION[1]

A. THE CHALLENGE OF ACCESS

In developing new technology, an engineer must always make an important strategic decision: what fractions of available time and money should be spent on original research and invention, and what fractions should be spent on finding out what has already been done by someone else.

Similar choices confront decision makers at higher levels. Corporate technology managers must decide on what fractions of their resources to invest in research and engineers versus information acquisition and librarians. Owners of companies must decide whether to develop new technology in-house or to acquire it by licensing new technology from another company or buying another company that has already developed a new idea. Governments must decide whether to support technology development by underwriting the search for new knowledge or by underwriting the acquisition and dissemination of knowledge obtained elsewhere.

Rarely are decisions about allocating resources between developing and acquiring new knowledge stated quite so sharply. Instead, it has been the practice to view research and development (R&D) as the primary activity, and to treat acquisition of external knowledge as a necessary overhead on R&D. For

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[1] For an earlier and closely related CRS report see, Nancy R. Miller, "Japanese Science and Technology: Some Recent Efforts to Improve U.S. Monitoring," Congressional Research Service Report No. 86-195 SPR, December 22, 1986.

example, it has always been a part of "good science" for a researcher to carry out a literature review before beginning original work in a field -- every graduate student is taught this practice. Most Federal agencies that support external research require potential contractors and grantees to submit formal written proposals for funding that include a review of the relevant background literature. Similarly, engineers in a company who are working on a new technology are expected to use available literature, handbooks, professional networks, and the like to enrich their understanding of the area in which they are working.

The growing size and scope of the scientific and technical enterprise worldwide has rendered this informal approach to external information gathering increasingly ineffective. The vastly greater and rapidly growing numbers of researchers, publications, and patents have compounded the challenge of keeping up with developments elsewhere.

Another important change is the emergence at the forefront of science and technology of such nations as Japan, China, Korea, and the Soviet Union. The scientific and technical literatures of these nations are typically written in their respective languages. Gone are the days when educated American scientists and engineers could stay abreast of nearly everything of significance in their fields with a command of English and a reading knowledge of German. However, most practicing American scientists and engineers know only English and perhaps a smattering of a European language such as French or Spanish.

Also gone are the days when an American researcher could presume that America is the leading nation in technology. While this country continues to hold a commanding lead in basic scientific research in nearly every field, state-of-the-art technologies increasingly originate elsewhere, and the latest

advances in even well-established fields are often made by firms and engineers in other countries. Knowledge only of the English-language literature and the American scene is thus inadequate as the basis for understanding what is already known in many areas of technology.

Much has been written about the challenge of getting more effective access to scientific and technical information, especially from Japan but also from Korea, China, and other emerging industrial nations[2]. Among the sources cited are the proceedings of a number of specialized conferences and hearings convened to discuss how more effective access might be achieved. It has been a conclusion of nearly every study, conference, and report -- contravened by none

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[2] See, for example, the following selection of key documentation and analyses: Nancy R. Miller, op cit.; National Academy of Engineering, "Strengthening U.S. Engineering Through International Cooperation: Some Recommendations for Action," Washington, D.C., 1987; Clay Chandler, "U.S. Industry Cool to Tracking Japan's High-Tech Publications: Translators Report They Have Little Work," Washington Post, September 8, 1987, page D1; E. Bruce Peters, editor, "Monitoring Foreign Science and Technology for Enhanced International Competitiveness: Defining U.S. Needs," Proceedings of the Office of Naval Research and National Science Foundation Workshop, Washington, D.C., October 5-7, 1986 [hereinafter, Peters, 1986]; Wayne S. Kiyosaki, "Japanese High-Tech Information: A Beckoning Market," Office of Training and Education, Central Intelligence Agency, undated, (1986?); Edward L. Brady, editor, "U.S. Access to Japanese Technical Literature: Electronics and Electrical Engineering," National Bureau of Standards, U.S. Department of Commerce, NBS Special Publication 710, January 1986; Paul Rubin, "How to Monitor High Tech in Japan," The Journal of the American Chamber of Commerce in Japan, April 1986, pages 43-48; "The Role of Technical Information in U.S. Competitiveness with Japan," Hearings before the Subcommittee on Science, Research and Technology, Committee on Science and Technology, House of Representatives, 99th Congress, 1st Session, No. 27, June 26, 27, 1985 [hereinafter, Hearings, 1985]; National Science Foundation, "U.S. Access to Japanese Scientific and Technical Literature," National Science Foundation Report to the House Committee on Science and Technology, April 1985; Nancy R. Miller, "The Availability of Japanese Scientific and Technical Information in the United States," report prepared by the Congressional Research Service for the Subcommittee on Science, Research and Technology, Committee on Science and Technology, U.S. House of Representatives, 98th Congress, 2nd Session, Serial LL, November 1984; Andrew Pollack, "Japan Technology Monitored by Worried U.S. Competitors," The New York Times, May 7, 1984, page 1; "The Availability of Japanese Scientific and Technical Information in the United States," hearings before the Subcommittee on Science, Research, and Technology, Committee on Science and Technology, House of Representatives, 98th Congress, 2nd Session, No. 95, March 6, 7, 1984 [hereinafter, Hearings, 1984].

of the sources cited above -- that at this time the problem of effective access to Japanese technical information is not that the Japanese are unwilling to share such information with Americans, but rather that America is neither willing nor prepared to take the actions needed to seek out that information and make it available to its engineers and scientists in a timely and effective manner. It has also been the assumption of each of these sources that Japan does have a large and growing body of interesting and important technical information that is not generally available in the United States, and that American scientists and engineers are reluctant to take advantage of this resource.

Numerous observers have speculated on the reasons that more effective use has not been made of foreign origin technical information in the Unites States. Often interpreted as a lack of demand for information from abroad, this has been attributed to the prevalence of the "not invented here" syndrome, to a general lack of understanding of the state of Japanese technical knowledge due to the fact that so few Americans can read the language, to the belief on the part of Americans that Japanese success in high-technology goods is due to factors other than their advanced knowledge of science and engineering, or even to the view among American managers and other professionals that foreign travel by engineers and scientists is a "boondoggle," rather than a serious attempt to learn about technologies held overseas. Whatever the reasons for the perceived inadequate demand for Japanese scientific and technical information, many persons, both in Government and out, have perceived the enhancement of access to such information as a challenge that must be addressed.

Congress and the Administration have already responded to this challenge. In 1986, Congress passed the Japanese Technical Literature Act (P.L.99-382) and the Federal Technology Transfer Act (P.L.99-502) to help facilitate such

access. Various Federal agencies had already been accessing certain aspects of Japanese technical literature[3], and on April 10, 1987, President Reagan issued Executive Order 12591 which calls upon the National Science Foundation, the Department of Commerce, and the Department of State to "...develop a central mechanism for the prompt and efficient dissemination of science and technology information developed abroad."[4] The omnibus trade bills currently in conference between the House of Representatives and the Senate contain several provisions related to access to foreign scientific and technical information.

B. SCOPE OF THIS REPORT

This report develops a conceptual framework within which discussion of policy options to improve access to Japanese and other foreign scientific and technical information might take place. It presents a policy analytic perspective on rationales for and against a Federal role in such access, and it discusses the pros and cons of proposals for a greater Federal role in the future. Legislative proposals to enhance access to foreign technical information are summarized. The report also describes several options for enhancing U.S. access and offers estimates of their costs.

Three considerations limit the scope of this report: types of information, sources of information, and supply versus demand for information. First, it focuses on scientific and engineering information likely to be of use to

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[3] See, for example, Nancy R. Miller, op cit., and National Academy of Engineering, op cit., for summaries of such ongoing activities.

[4] Ronald W. Reagan, "Facilitating Access to Science and Technology," Executive Order 12591, April 10, 1987. For a review of actions taken under the executive order regarding access to foreign technical information, see the testimony of John H. Moore, Deputy Director of the National Science Foundation before the Subcommittee on Science, Research and Technology of the House Committee on Science, Space and Technology, July 15, 1987.

technical personnel in industry or to those working in universities, Government laboratories and agencies, or other organizations concerned with industrial technology. This in not to say that other types of information are not relevant (such as the results of basic research generally, information on official and industry standards, commercial and market related information, or information on science and technology policies), but that they are not the primary focus of this report.

Second, the sources of information of primary interest to this report are all sources other than information held as private property by industry. That is, the report is concerned with information openly available from published and unpublished sources such as non-proprietary industry, government laboratories, research consortia, and universities. The other major category of information, that which is held in private ownership, poses an entirely different set of challenges. Typically, if they are aware of its existence, U.S. firms can arrange for access to such information through ordinary market channels such as direct purchase, licensing agreements, joint ventures, or taking equity positions in Japanese firms.

Third, the focus of the report is on enhancing the supply of Japanese technical information, rather than on stimulating demand for it. The latter is largely a matter of modifying the attitudes and behavior of engineers and scientists to take advantage of information from abroad, and that is likely to happen slowly so long as the supply remains limited and expensive. Whether the demand would increase in response to more favorable supply remains uncertain.

II. A FRAMEWORK FOR CONSIDERING THE FEDERAL ROLE IN INFORMATION ACCESS

It is not unusual to hear forceful statements of the view that the Federal Government has no business getting involved in access to foreign scientific and technical information, and equally forceful statements that the Government must act with vigor and dispatch in this area.[5] Aside from being statements of political preferences, how might we understand these postures? This section first addresses rationales for, and then arguments against, a Federal role in access to foreign scientific and technical information.

A. RATIONALES FOR A FEDERAL ROLE IN ACCESSING FOREIGN TECHNICAL INFORMATION

A number of rationales can be offered for a Federal role in access to foreign technical information. The first is that the mission agencies of Government need to know what is going on and what is available in other nations for their own, unique purposes. These purposes range from national security, to energy and space research, to the procurement of routine civilian goods and services for its offices and infrastructural facilities. Federal involvement in technology-related intelligence activities for national security purposes is

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[5] The Public Sector/Private Sector Task Force report to the National Commission on Libraries and Information Services addressed these issues in equally stark terms. See, "Public Sector/Private Sector Interaction in Providing Information Services," National Commission on Libraries and Information Science, February 1, 1982, especially page 33.

well established, and a substantial although not generally known portion of that activity is devoted to assessing the technological status and capabilities of other nations.[6] Such agencies as the Department of Energy, the National Aeronautics and Space Administration, and the National Science Foundation have long devoted some resources to following technical developments overseas.

A second rationale for a Federal role in accessing foreign technical information is that the Government has reserved to itself certain functions upon which private parties necessarily depend. Typically, business must seek the assistance of the Government in overcoming official barriers to information access erected by other nations. For example, private firms are not in a position to negotiate with foreign governments regarding their rules that limit participation in cooperative industrial research programs to domestic firms. Similarly, private firms are not permitted to forego restrictions on the transhipment of data imposed under the Export Administration Act in return for access to other data held by the receiving nation.

A third rationale for a Federal role in accessing foreign technical information arises from consideration of ways in which the private marketplace, left to its own devices, may fail to invest optimally in acquiring technical intelligence. Such "market failures" arise frequently in the market for information.[7] One of these market failures is the fact that significant

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[6] The existence of such assessments motivates periodic calls for their release to the general public when such release would not jeopardize national security. See, for example, the testimony of Anthony Polsky, President, Cathay Counsellors Group, Inc., in Hearings, 1984, pages 73-82. This issue also arose in the conference held by the Office of Naval Research and the National Science Foundation, see, E. Bruce Peters, op cit.

[7] For a lengthy discussion of the concept of market failure in information markets, see Chapter 6, "Technology, Intellectual Property, and the Operation of Information Markets," in, U.S. Office of Technology Assessment, Intellectual Property Rights in an Age of Electronics and Information, Report OTA-CIT-302, April 1986 [hereinafter, OTA, 1986].

"spill-over" benefits accrue to all firms from the collection and dissemination of foreign technical information that cannot be captured by the firm that pays for the collection. Once someone has generated some new information, it is quite difficult, in law and in practice, to prohibit its use by someone else or to compel other users to pay a fair price for it. Especially with modern technologies of communication and duplication, it is cheaper to copy information than it is to gather it in the first place. This "lack of appropriability" of the benefits of access activities creates an incentive for those who need information to wait until someone else obtains it so they can copy it, with the result that the overall level of investment in information acquisition is less than economically optimal. That is to say, the supply of acquired foreign technical information will be too low in a free market.

Market failure also arises from the fact that it is difficult to know whether one needs a particular piece of information until one has seen it, and at the point one sees it, one "has" it. The limitations of the property rights surrounding information make the information that one "has" at least partially usable without payment of just compensation.[8] In practical terms, this characteristic of information also means that it is difficult to initiate a new information-providing service in the private market, because one's potential customers either do not know they need the service or cannot judge how valuable the service would be to them. There are large "transactions costs" in aggregating the market for the product, and there is high uncertainty as to the ultimate size of that market. This profound uncertainty about the nature of unknown information means that in a free market there is also a shortfall in

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[8] This aspect of the market for information was noted by the Nobel Prize-winning economist Kenneth Arrow. See, Kenneth J. Arrow, "Economic Welfare and the Allocation of Resources to Invention," in, Economics of Information and Knowledge, D.M. Lamberton, ed., Penguin Books, 1971, page 148, quoted in, OTA, 1986, page 167.

the demand for information compared with what there would be if users knew the content of the information before they had to decide whether to pay for it. Demand shortfall exists, therefore, in both the start-up phase of a new service and, to a lesser extent, permanently.

A fourth rationale for Federal involvement in assuring access to foreign technical information lies in the fact that such access can improve the effectiveness of Federal support of research and technology development in the universities and industry.[9] The very fact of government subsidy for basic research, particularly in universities, creates a bias in favor of generating original knowledge as opposed to improving the accessibility of existing knowledge from overseas. That is, Government subsidy of basic research reinforces the tendency of the academic community to hold contributions to new knowledge in higher esteem than acquisition and codification of existing knowledge.[10] Thus, it is argued that Federal subsidy for foreign information

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[9] A closely related, but different, argument has been made that the Federal Government could enhance the economic return to its own large investments in research and development by investing in improved systems for evaluation, integration, and end user packaging of the resulting information. See, for example, Lewis M. Branscomb, "Improving R&D Productivity: the Federal Role," in, Towards a National S&T Data Policy, Collected Presentations at a workshop coordinated by the Committee on Science and Technology, U.S. House of Representatives, the Congressional Research Service, and the Numerical Data Advisory Board of the National Academy of Sciences, Washington, D.C., April 14, 1983, page 4.

[10] The influence of Federal research support on the culture of the universities has been substantial. For example it has been argued that Federal funding of research in universities has enhanced the power of the traditional academic disciplines at the expense of interdisciplinary studies, problem solving, teaching, and administration. See, Daniel Alpert, "Performance and Paralysis: The Organizational Context of the American Research University," Journal of Higher Education, Vol. 56, No. 3, May/June 1985, pages 241-281. Also, William Guns has noted that, "Getting 'real work' done is an American cultural trait...[and that an]...attitude exists in the U.S. that reading and evaluating are not as important as empirical work." See, William D. Guns, "The Demand for Information About S&T in Japan and Western Europe: Another Approach," in, E. Bruce Peters, op cit., page 40.

access can help to offset the bias created by the otherwise desirable and established support of research at universities.

B. RATIONALES AGAINST A FEDERAL ROLE IN ACCESSING FOREIGN TECHNICAL INFORMATION

There are limits to the implications of each of the rationales for a Government role in accessing technical information from abroad. First, regardless of the strength of the market failure rationales for Federal involvement, it is not clear that the Government can do anything effective to offset the market failures. Typically, Government agencies are distant from the marketplace and have limited appreciation for the needs of private parties. Furthermore, well-established traditions of fairness, openness, and accountability work to maintain that distance, regardless of the determination of Federal employees to overcome it. The delays resulting from these traditions, which are endemic to Government programs, can reduce the effectiveness of Government actions as compared with private ones. Salary limitations and job classification requirements may make it difficult for Government agencies to maintain the skills necessary to manage highly technical programs.

Second, firms that wish to access foreign technical information are not always powerless in the face of foreign government barriers. For example, large U.S. firms that wish to access Japanese technical information and capabilities have made a variety of investments there, including establishing a field office, setting up a manufacturing subsidiary, entering into a joint venture with a Japanese firm, and locating a full-fledged research and development center in the country. In negotiating participation in Japanese-government coordinated cooperative R&D programs, U.S. firms can seek to trade

access to some of their own confidential information for the right to participate. U.S. firms can contract with foreign national consultants for intelligence gathering in their home countries, and they can train their employees in foreign languages to improve their entre' to the overseas community.[11]

Third, despite the prima facie case that can be made that market failure is endemic to the information and intelligence markets, in fact, large and profitable firms serve these markets today. Thus, the "market failures" are a not absolute but a matter of degree. In the case of access to foreign scientific and technical information, some private parties do supply such intelligence, and some private parties do buy it, often at high prices. Perhaps the most important determinants of the profitability of this kind of private business are the timeliness, accuracy, and relevance of the information that is provided to the user. Furthermore, spill-overs to other potential users can be prevented in part by copyright, which creates enforceable property rights in some kinds of information, and in part because the buyers have a strong incentive not to share information, for which they have paid, with other potential users. As a rule, the buyers who can pay high prices are large firms or firms in highly competitive markets in which detailed knowledge of competitors' technologies has especially high value.[12]

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[11] These observations suggest that small and medium-sized firms, which have less political influence and which face greater costs of acquisition of information compared with their sales and profits than large firms, may have more to gain from publicly-assisted information access programs than larger firms.

[12] It is likely, however, that some potential users of foreign technical information are not willing or able to pay the market prices that result from restricted supply. These potential users are small firms or those for which the expected benefits of the information, while positive, are too small to justify the overhead costs associated with its acquisition for a single user.

Finally, if the Federal Government needs foreign scientific and technical information for its own purposes, such as defense and space, it has the option to obtain that information in the market from private sources rather than to mount its own program of access.

C. OBSERVATIONS ON THE PROS AND CONS OF A FEDERAL ROLE

Obtaining and using foreign scientific and technical information is a multi-step procedure, as discussed in the next section of this report, ranging from obtaining the legal right to access, to the adaptation of such information for commercial or public purposes. The "market failures" and other aspects of access that condition the debate over the Federal Government's role differ in kind and degree among the various stages of the access process. Thus, additional insight into what the Federal Government might do effectively and appropriately to assure access may be obtained through more detailed consideration of the various stages. The following sections of this report take this approach.

The needs, limitations, and policy roles for information access also differ among the various types of information and intelligence that are being sought. For example, scientific information in the sense of information about, and theoretical understanding of, how the natural world works already flows relatively freely across national boundaries. While not always followed explicitly, the canons of good science call for open dissemination and access to scientific information by all through such mechanisms as conferences, preprints, and open publication via doctoral dissertations and scientific journals. Technical and engineering information is more closely held by its generators and owners because it has greater or more immediate commercial and/or military value than, and is less likely to be published than scientific

information. When technical information is published it is likely to be in a style and format that does not convey complete understanding of relevant details and principles. Commercial and business information is even more tightly held and is rarely published, except to demonstrate that the writer knows a great deal more than he is willing to say unless he is compensated for releasing it[13]. Americans have relatively little difficulty in getting effective access to basic scientific results from Japan. The major focus of American interest in Japanese scientific and technical information is in its engineering and technical information relevant to commercial technology and business practice, rather than in its more limited (although rapidly growing) science base.

The market failure arguments summarized above, which might be seen as rationalizing a Federal role in accessing foreign technical information, do not provide much guidance about the specific form of that role or about the level of support that might be economically optimal. Furthermore, because of the market failures, the prices that are observed in the market are not necessarily good signals of the real value of the information to users, and the expressed willingness, or unwillingness of potential users to pay for such information is also an imperfect guide to the appropriate level of involvement. It has proved to be difficult in practice to elucidate even gross estimates of the demand for information about Japanese technology.[14] Finally, it should be kept in mind that Federal information policy in general is much more complex in practice than is suggested by the theoretical arguments pro and con offered above. Any

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[13] The technical, professional, and trade press is replete with what are essentially advertisements thinly disguised as technical papers.

[14] The conference sponsored by the Office of Naval Research and the National Science Foundation in October 1986 was designed to elicit expressions of potential demand, with only limited success. See, E. Bruce Peters, op cit.

major Federal program to improve access to Japanese technical literature would encounter the usual debates regarding the roles of various Federal agencies, the locus of responsibility for managing the Federal information resource, privacy, equity of access, cost recovery, paperwork reduction, and all the rest.[15]

In a broader sense, however, a Federal role in accessing foreign technical information has already been authorized, through the passage of the Japanese Technical Literature Act, P.L. 99-382, and the Federal Technology Transfer Act, P.L. 99-502, as well as through the promulgation of Executive Order 12591, which directs the Departments of State and Commerce and the National Science Foundation to develop a program to assure effective access to foreign scientific and technical information. The salient issues for this study have to do with whether and how that role might be changed and the costs and benefits of such changes.

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[15] For comprehensive treatments of these sorts of issues, see, Peter Hernon and Charles R. McClure, Federal Information Policies in the 1980's: Conflicts and Issues, Ablex Publishing Corporation, Norwood, New Jersey, 1987; Timothy I. Adams, et al., "Improving the Transfer and Use of Scientific and Technical Information: The Federal Role," report to the National Science Foundation by the Science and Public Policy Program, The University of Oklahoma, November 1986; Michael R. Rubin, Information Economics and Policy in the United States, Libraries Unlimited, Littleton, Colorado, 1983; and National Commission on Libraries and Information Science, op cit.

III. STAGES IN THE PROCESS OF INFORMATION ACCESS

It is useful to conceive of access to foreign scientific and technical information in terms of a series of steps or stages. Not all steps are required in every circumstance, nor are they necessarily sequential. Each step may be supported and performed by different parties. The steps discussed here are:

- assuring legal access
- selecting relevant information to acquire
- acquiring technical information
- translating acquired information
- disseminating information
- interpreting information, and
- evaluating access procedures and performance.

A. ASSURING LEGAL ACCESS

Access to some, but by no means all, relevant foreign scientific and technical information is inhibited by legal barriers. At one extreme, nations may have conferred private property rights on the holders of certain information using such mechanisms as patents, copyrights, and trademarks. Further, in order to protect information, national laws may constrain the terms

of private contracts for information access, including the use and enforcement of trade secrets. Security systems established for reasons of state, such as national security or, in some cases commercial security, also constrain legal access to certain information.

In connection with access to Japanese technical information, the consensus of professionals involved in the field is that the major problems of access lie within the practices, attitudes, and capabilities of the United States, and that the barriers to access within Japan are of much less importance. Summarizing the findings of a number of prior meetings and discussions during the last several years, the editor of the proceedings of the ONR/NSF workshop wrote:

> Barriers to access and acquisition of Japanese S&T information was another question addressed in these forums. While there was some concern expressed about Japanese barriers to access, such as copyright requirements...the major impediments identified were on the U.S. side: weak Japanese language and translation capabilities; insufficient use of face-to-face communication to assess Japanese research; [and] outdated views about the current quality of Japanese S&T, fueled by a "not invented here" syndrome in the United States.[16]

In considering the possibility of access, it should also be considered that Japanese firms are in business to make a profit by selling products and capabilities at home and abroad. Thus, they and the Japanese government have an incentive to make their capabilities known around the world for good business reasons. The Japanese External Trade Organization, for example, publishes a monthly journal entitled, New Technology Japan, whose express aim

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[16] E. Bruce Peters, op cit., page 2.

is "...to promote the international exchange of technology through the introduction of Japanese New Technology."[17]

Individual firms and citizens can do little to overcome systemic legal barriers to information access in the general case. Specific items of information can, of course, be sought via, for example, licensing agreements with patent holders. More generally, however, where legal barriers do exist, there is little choice but to seek state intervention to gain access to information. For example, agreements to make classified information available across borders by their nature require government action. Similarly, if national policy restricts access to government-sponsored research programs of commercial interest, then foreign firms must usually have the support of their own governments to gain the right to participate.

Executive Order 12591 issued to implement P.L. 99-502, the Federal Technology Transfer Act of 1986, makes reciprocal access an explicit negotiating point at Section 4(a)(1):

> In order to ensure that the United States benefits from and fully exploits scientific research and technology developed abroad, (a) The head of each Executive department and agency, when negotiating or entering into cooperative research and development agreements and licensing arrangements with foreign persons or industrial organizations (where these entities are directly or indirectly controlled by a foreign company or government), shall, in consultation with the United States Trade Representative, give appropriate consideration: (1) to whether such foreign companies or governments permit and encourage United States agencies, organizations, or persons to enter into cooperative research and development agreements and licensing arrangements on a comparable basis....

Bills have also been introduced in the 100th Congress to make reciprocal access to foreign technology a consideration in trade negotiations. For example, the Senate version of H.R. 3, The Omnibus Trade and Competitiveness

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[17] Japanese External Trade Organization, Machinery and Technology Department, New Technology Japan, Volume 14, Number 6, September 1986, inside front cover.

Act of 1987, passed on July 21, 1987, would establish pursuant to Section 3871 an interagency Committee on Symmetrical Access to Technological Research. This committee would study the concept of symmetrical access and make recommendations to the United States Trade Representative (USTR) regarding negotiating goals which would seek to increase the degree of symmetrical access to technological research between the United States and foreign countries. It would report annually to Congress on, among other things, the progress made by the USTR in achieving the recommended goals.

In contrast, however, because of concern for both national security and economic competitiveness, a trend has emerged recently toward the erection of barriers to access by foreigners to American commercially related Government-assisted research and development programs and their resulting technical information. Some have argued that this trend away from openness in the United States could make assuring effective access to technical information from other countries more difficult.

The trend toward closing off access to technical information in the United States can be illustrated by the history of recent legislation and administrative actions related to civilian R&D programs.[18] Passed in 1980, the Stevenson-Wydler Technology Innovation Act, P.L.96-480 (which among other provisions encourages transfer of Federal technology to industry and establishment of cooperative industrial research programs under both NSF and the Department of Commerce) makes no mention of limiting such access to

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[18] Controls on the export of U.S. scientific and technical information and technology imposed under the Export Administration Act of 1979 pose additional barriers to foreign access to U.S. information, including that related to so-called dual-use technologies. See, for example, Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, Balancing the National Interest: U.S. National Security Export Controls and Global Economic Competition, Washington, D.C.: National Academy Press, 1987 (the "Allen Report").

American companies. Adopted six years later, Section 12(c)(4) of the Federal Technology Transfer Act of 1986, P.L.99-502, however, says in connection with Federal laboratory cooperative agreements with industry:

> ...the laboratory director in deciding what cooperative research and development agreements to enter into shall...(B) give preference to business units located in the United States which agree that products embodying inventions made under the cooperative research and development agreement or produced through the use of such inventions will be manufactured substantially in the United States and, in the case of any industrial organization or other person subject to the control of a foreign company or government, as appropriate, take into consideration whether or not such foreign government permits United States agencies, organizations, or other persons to enter into cooperative research and development agreements and licensing agreements.

The House and Senate trade bills further strengthen these kinds of restrictions on foreign participation in U.S. R&D programs. Each has numerous provisions directing that various types of research and technology assistance and cooperation be limited to U.S. businesses. The recent Federal Conference on Commercial Applications of Superconductivity, organized by the Department of Energy and the Office of Science and Technology Policy in Washington on July 28 and 29, 1987, denied attendance to representatives of foreign firms and to members of the diplomatic delegations of foreign nations, although members of the foreign press were admitted.[19] And, in a related matter, the newly-formed Superconductivity Applications Center at Argonne National Laboratory has instituted an industrial affiliates program in which Japanese firms will not be eligible for membership, and in which it has not been determined whether U.S. firms engaged in joint ventures with Japanese firms will be allowed to participate.[20]

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[19] Michael Specter, "Superconductivity Conference to Exclude Foreign Officials," Washington Post, July 25, 1987.

[20] Wil Lepkowski, "Superconductivity Drive Sparks New Policy Debates," Chemical and Engineering News, September 7, 1987, pages 10 to 14.

B. SELECTING RELEVANT INFORMATION TO ACQUIRE

Selecting relevant information to acquire is probably the most challenging step in information access, because of the enormous amount of information that is available and because of the difficulty of knowing what it is that potential users might find useful. The vast supply of potentially useful information in such countries as Japan or Korea makes comprehensive translation prior to selection a logistical impossibility[21]. Therefore, much of the selection process must go on in the language of origin of the material or through wide-ranging conversations with bilingual persons who are experts in the fields of interest.

To cope with this demand uncertainty, agents responsible for selection of information to acquire must attempt to understand the disparate needs of unknown clients in a variety of sectors. Private firms, if at all diversified, are unlikely to be able to articulate an adequate statement of "user need" to information transfer agents, and, of course, any particular agent would typically try to serve the needs of many firms. The result is that any conceivable system of selection is likely to cast its net either too widely or too narrowly to be of maximum utility to users; one suspects this outcome is inevitable. Some information will be omitted that might have been useful, while, from the perspective of any particular user, any system will select a great deal of irrelevant information. Automated indexing and dissemination technologies can make the search process more effective and efficient for

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[21] See Section V for an estimate of the cost of translating only the Japanese technical literature into English. Furthermore, the magnitude of the task overwhelms the capabilities of the available corps of translators in the United States.

individual users, but cannot eliminate overselection/underselection of materials for the community of users as a whole.

The selection process must involve subject matter experts to be effective. It cannot be left to translators who have no basis for judging what may be of technical or commercial importance. This, coupled with the great volume of relevant literature to be considered from such countries as Japan and West Germany, suggests that it would be most effective for "selection" to occur insofar as feasible prior to translation. This, in turn, suggests that subject matter experts who are in direct contact with working members of the technical communities in target countries can carry out the selection process most effectively. Experts must be "on the ground" in the country for greatest effectiveness.

C. ACQUIRING TECHNICAL INFORMATION

In the countries of interest to this report, an important part of the relevant technical information is published or otherwise made available in public fora such as workshops and conferences; often long before, or instead of, appearing in formal print. Thus, acquisition is principally limited by cost, rather than availability, but timely access depends on participation in these meetings. Often the original form of the information is inconvenient for potential end users, so some degree of processing and summarizing may be necessary, even before the information is made available to interpreters and analysts.

The cost issue is non-trivial. For example, it has been estimated that over 10,000 scientific and technical journals are published in Japan[22]. At an

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[22] Testimony of Justin Bloom in Hearings, 1984, pages 4 and 10.

(arbitrarily estimated) average price of $100 per year for air-mailed subscriptions, it would cost $1 million per year just to subscribe to all of them. Acquiring the ephemeral information available at workshops and conferences may cost much more, since attendance involves direct labor, travel and subsistence costs for participating technical professionals; and since, to be effective, U.S. agents must become active participants in the relevant technical communities, not just occasional visitors.

D. TRANSLATING TECHNICAL INFORMATION

Translation is frequently understood to be the key step in information access, and, in one sense it is -- someone in the process must be able to understand both languages. However, the role of formal translation of primary literature has probably been overstated in several respects. First, insofar as technical and commercially-related information is concerned, the primary scientific literature is of secondary importance as compared with literature of a more applied or practical nature.

Second, formal translation of published technical articles and materials can introduce significant delay into the access process. For many commercial users of technical information, this lack of timeliness can render translations of little use. Such users need to be in closer contact with on-going work in the country of interest.

Third, studies have shown that engineers in industry read relatively few journal articles in the course of their work, even in English.[23] For most

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[23] One study found that engineers involved in research and development in the United States spend an average of five hours per month reading journal articles, and that they read an average of 6.4 articles per month. This is not to say that engineers are especially prone to avoid professional reading. The same study found that physical scientists read on average 15.8 articles per month; mathematicians, 5.1; and life scientists, 15.0. See, Donald W. King, et

engineers, reading individual journal articles is not an efficient way to keep abreast of new developments or to gain in-depth knowledge of a new field. Instead, they typically depend on personal contacts with knowledgeable contacts, both coworkers and those outside, and on less formal sources such as trade shows and professional meetings. If engineers read few primary articles in English, it is unlikely that they would add any significant number of Japanese translations to their list of high-priority items to read.

Fourth, a great deal of the primary research literature in both science and engineering reports on relatively marginal contributions to the corpus of understanding -- it is important to the internal dynamics of science but not of critical importance to the world of applications. Thus, such literature need not be translated in detail, if at all, but it is important to have a general idea of trends in the various fields. A sense for trends can be gained better through personal discussions with working scientists than through perusal of mountains of translations. Furthermore, in order to identify whether a particular publication is worthy of more detailed translation, someone must be able to scan and judge it, and this requires an understanding of the field as a whole, not only the language.

Finally, it has been found that doing effective translation of scientific and technical information from the Japanese requires not only language skills but also sophisticated understanding of the substance of the field being translated. Otherwise, ambiguities and difficulties in translating accurately seem to overwhelm most non-technical translators. This poses two further problems. One is that at most only a few hundred Americans are both trained in

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al., "Value of the Energy Data Base," report submitted to the Technical Information Center, U.S. Department of Energy, Oak Ridge, TN, by King Research, Inc., Rockville, MD, March 31, 1982, page 19.

science and engineering and able to translate Japanese to English.[24] The other is that the demand for bilingual scientists and engineers has not yet grown sufficiently to encourage young people to enter this grueling double course of study.

A number of ways out of the translation problem have been suggested. One is to contract for translation with Japanese nationals, of whom there are many more who speak English than there are Americans who speak Japanese. Some have raised questions about whether this leaves American users vulnerable to filtering of information by persons who may have divided loyalties, although a number of companies employ Japanese nationals successfully for this purpose. Another approach to the problem of limited translation resources is to target them on high priority sources, such as review articles or publications by leading researchers in each field. Another is to depend less on translation and more on personal contact. Yet another is to depend on American translators who are not trained in science or engineering to do much of the detailed translation, with help from the few technically trained translators. Still another approach is machine translation, but this still needs a great deal of research and development to become routine. In addition to the difficult linguistic problems encountered in machine translation, its use to translate Japanese into English by Americans awaits the development of optical character readers that can enter Japanese characters into a computer automatically and that can cope with graphical and tabular information as well as text.[25]

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[24] Clay Chandler, op cit.; Wayne S. Kiyosaki, op cit.; National Science Foundation, 1985, op cit.

[25] Tamami Kusuda, "Japanese Technical Literature Act and Machine Translation," unpublished paper presented on behalf of the U.S. Department of Commerce at the Machine Translation Summit conference, Hakone, Japan, September 13-20, 1987.

E. DISSEMINATING INFORMATION

Information, or intelligence, about developments in foreign science and technology is of little use unless it is put in the hands of those who are in a position to use it; generally working engineers and technical managers. Potential users must, in turn, be able to discern the small amount of usable nuggets from the great mounds of raw material offered up to them.

Passive modes of dissemination, such as publication in a technical journal, deposit of a report at the National Technical Information Service, or inclusion in a computerized bibliographic data base are necessary archival components of a dissemation system. However, to be useful to competitors, intelligence on developments abroad must be brought to the attention of potential users quickly and pointedly. This suggests the employment of technical and professional societies, which exist largely to keep their members informed, as major channels of dissemination of such data. Their semi-technical publications, meetings, newsletters, and specialized translation journals can be useful outlets. Even as the Federal Government subsidizes the production of a considerable fraction of the primary original studies reported through these mechanisms, it may want to consider whether subsidizing the technical intelligence dissemination function through these channels might be appropriate and cost-effective.

F. INTERPRETING INFORMATION

Interpretation of scientific and technical information from overseas is a necessary component of each step in the process, from deciding which countries and fields to track, to deciding whether a given piece of data might be useful to industry, to using the new data in the design of a new product or in

deciding whether to attempt to enter a new technological field. In each case, the value of new information can be judged only in the context of potential utility. Because the utility is potential, rather than assured, each interpretive step is necessarily uncertain and judgmental. In such circumstances, it may be most effective to assure the existence of more than one parallel channel of access, and to ensure that each channel is exquisitely sensitive to feedback received from the user community regarding the worth of what is being made available.

Government and its civilian employees are not generally in a position to judge the commercial utility of foreign-origin technical information. Only in unusual and highly visible areas such as superconductivity or electric automobile technology, in which the Government has made a substantial investment in its own technical personnel, is a Government agency likely to be able to make informed judgments about the commercial utility of new technical information. On the other hand, Government may be in a good strategic position to financially support this task through, or on behalf of, commercial users, in view of the positive spill-over benefits from information access. Thus, grants or contracts to non-governmental entities may be more effective for accessing such information than Government performance of the service using its own employees.

G. EVALUATING ACCESS PROCEDURES AND PERFORMANCE

How would one know whether a foreign technical information access program were working? One measure could be evidence of market demand for such information, yet the very external benefits and other market failures discussed earlier in this report render market demand an inadequate measure of need or its satisfaction. Similarly, asking users or potential users about their

experiences with a program or about their willingness to pay for its products is subject to biases -- users who benefit from a system may overstate its value in order to try to assure its continuation, while those who do not benefit may understate its value in the attempt to reduce their taxes. Furthermore, some potential users may suffer from inadequate exposure to its products or may not even realize that they are using its products indirectly via what they learn through secondary and tertiary dissemination channels such as professional journals. Finally, some parties who are spending their own resources for information access may prefer to inhibit public program development in order to avoid assisting their potential competitors.

Nevertheless, there may be a need for some individual or institution to pay attention to whether systems are working and whether the nation is getting all it could from its investment of resources in foreign information access. On the one hand, coordination may be required to ensure that something is being done at each critical step, while, on the other, it is unreasonable to expect the advocates of a program to carry out an unbiased evaluation of their efforts. Nevertheless, those responsible for the system must also be kept apprised of how it, and they, are doing, via maintenance of communications between performers and evaluators[26].

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[26] Executive Order 12591 directs the Secretaries of State and Commerce and the Director of the National Science Foundation to develop a central mechanism for dissemination of foreign scientific and technical information. And, Section (d)(1)(D) of the Japanese Technical Literature Act directs the Secretary of Commerce to "... coordinate with [emphasis added] other agencies and departments...to identify significant gaps and avoid duplication in efforts by the Federal Government to acquire, translate, index, and disseminate Japanese technical information." The Secretary is also to report to Congress on such activities with respect to declassified Japanese scientific and technical information.

Under the auspices of the Federal Coordinating Committee on Science, Engineering and Technology, the Office of Science and Technology Policy has established a Working Group on International Education, Infrastructure, and Facilities of the Committee on International Science, Engineering, and Technology (CISET). As of April 1987, this working group has made a number of initial recommendations for actions by various agencies and departments to improve U.S. access to foreign scientific and technical information. See testimony of John H. Moore, op cit.

IV. PROGRAMMATIC OPTIONS FOR FEDERAL GOVERNMENT ACTION

A. THE CURRENT BASELINE FOR FEDERAL ACTION

Several Federal agencies are already involved in accessing foreign scientific and technical information, mostly to help meet their own missions. These include the Central Intelligence Agency; the Departments of Defense, Energy and Commerce; the National Science Foundation; and the National Aeronautics and Space Administration. The National Technical Information Service (NTIS) serves as a distribution point for such material.

The Japanese Technical Literature Act of 1986 gave statutory authority to the Department of Commerce to systematically collect, translate, and disseminate Japanese-language scientific and technical information of interest to industry, universities and government laboratories. Furthermore, under the Act the Department is to coordinate the efforts of other Federal agencies to gather Japanese literature and to seek ways to make it available. The Act authorized spending of $1 million in FY87; however, no appropriation was made to fund activities under the Act. The Department of Commerce is carrying out some activity under the Act during FY87 with reprogrammed funds in the total amount of $300,000 from NTIS, the Patent and Trademark Office, the

International Trade Administration, and the National Bureau of Standards[27]. The Department has recently established an Office of Japanese Scientific and Technical Literature, which is carrying out the reporting functions required under the Act.[28] For FY88, the Senate Committee on Commerce, Science, and Transportation has passed and reported S.907, which in Section 4402 authorizes $2 million for the Japanese Technical Literature Act; while H.R.2160, Section 5, reported by the House Committee on Science, Space, and Technology authorizes $1 million. The difference is expected to be resolved by the conference committee as a part of the conference on the omnibus trade bills.

Executive Order 12591 of April 10, 1987, directs the National Science Foundation, the Department of Commerce, and the Department of State to establish a system for accessing foreign scientific and technical literature. For some time, the NSF has maintained an office in Japan, and recently it has begun to make available for general distribution copies of reports that have been produced by its Tokyo office staff on Japanese scientific and technical developments, including science policy. On July 15, 1987, the Deputy Director of the National Science Foundation, John Moore, testified on the establishment of a new Information and Analysis Section in the Division of International Programs. This Section "...is charged with responsibility for the collection of information, reporting, analysis, and dissemination of final products to NSF management and staff, to other U.S. Government agencies, and to the U.S.

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[27] Kenneth Gordon, National Bureau of Standards, personal communication, September 4, 1987.

[28] Sabina G. Javits (Office of Japanese Scientific and Technical Literature, U.S. Department of Commerce), "The Japanese Technical Literature Program," paper presented at the International Conference on Japanese Information in Science, Technology and Commerce, University of Warwick, England, September 1-4, 1987.

scientific and engineering community in academia and industry."[29] This effort is not limited to Japan, although Japan is a major focus of the work to date.[30]

B. OPTIONS TO EXTEND CURRENT EFFORTS

Congress could decide to strengthen existing Federal efforts to access foreign scientific and technical information by appropriating funds for the various programs now underway. For example, specifically appropriated funds could help to implement the Japanese Technical Literature Act more fully. NSF could issue a periodic report containing its numerous staff papers on Japanese science and technology and policy and make it available on a subscription basis. The JTECH program (Japanese Technology Evaluation Program) of NSF, the Department of Commerce, and the Defense Advanced Research Projects Agency could be funded to carry out additional studies of the state of the art of particular fields. As illustrated below, each of these options could involve expenditures of up to several million dollars annually.

C. LEGISLATIVE PROPOSALS TO ENHANCE ACCESS TO FOREIGN TECHNICAL INFORMATION

The various contributions to the trade bills considered in this session of Congress have contained provisions to enhance U.S. access to foreign technical information. S.1233, the proposed Economic Competitiveness, International Trade, and Technology Development Act of 1987, contained two provisions relevant to information access. (S.1233 was part of the original Senate "trade bill", S. 1420, but many of its provisions were eliminated by a floor amendment

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[29] Testimony of John H. Moore, op cit.

[30] Charles T. Owens, NSF Information and Analysis Section, personal communication.

offered on July 23, 1987.) Its Subtitle H (Section 281 of S.1420 and now Section 3871 of the final Senate amendment to H.R.3) would establish an interagency, cabinet-level Committee on Symmetrical Access to Technology Research to "assess the idea of availability of equally valued technological knowledge in foreign countries and its implementation in trade negotiations." The Committee would be "charged with producing annual reports to Congress on this issue and setting negotiating goals for the United States Trade Representative [which would] be designed to increase the degree of access the U.S. has to technological knowledge and information in other countries."

Section 115 of S.1233 (which is no longer a part of the active trade bills) would have created a new Office of Technology Information within its proposed Department of Industry and Technology. This Office would "be responsible for the collection and analysis of data and information relevant to the development and use of technology, both domestic and foreign; for implementation of the provisions of the Japanese Technical Literature Act; for interagency coordination of such data and information, and for dissemination to the public." This Office would, in turn, include an Office of International Technology Monitoring and the National Technical Information Service. Had it been adopted into law, this provision of S.1233 would have provided statutory authority for comprehensive implementation of a program of worldwide information access similar to that now in place in Japan. A major concern would no doubt have been the cost of such a program, as well as the role that private and other non-profit participants might have played in it.

H.R.3, the House Omnibus Trade and Competitiveness bill, contains a Section 574, "Foreign Technical and Scientific Periodicals," which would amend the Higher Education Act to authorize $1 million for FY88 and other funds in the three subsequent years for the Secretary of Education to acquire,

translate, and disseminate technical and scientific periodicals published outside the United States and to disseminate translated periodicals so acquired to libraries, businesses, professional societies, and postsecondary education institutions. The Senate trade bill contains no corresponding provision.

D. USING THE TECHNICAL AND PROFESSIONAL SOCIETIES IN ACCESS

Recently, a number of American technical and professional societies in such fields as mechanical engineering, ceramics, magnetics, rheology, and automotive engineering have initiated programs to access, translate and disseminate foreign scientific and technical information, especially from Japan, to their members. Typically, these are based on publication of abstract journals on a periodic basis, and some can arrange for full-text translations of articles on demand.

While the information access programs of the technical societies may eventually become financially self-sustaining, the earlier discussion of "failures" in the market for information suggests that utilization of them may be less than optimal from a national point of view. Federal assistance -- temporary or continuing -- is an option that might help ensure the continuation of these programs. An agency such as the National Science Foundation or the Department of Commerce might be given the authority and budget to provide a partial subsidy of such efforts. Temporary subsidy for a period of, say, three years could help to overcome the start-up and market aggregation problems such efforts face, while a continuing subsidy could help overcome the high costs of operation as well as the risk that any particular item of foreign technical information might not prove useful in this country.

Subsidy could be offered directly or indirectly, and to the supply or the demand for information. Since the professional and technical societies are

non-profit organizations, tax incentives are unlikely to be useful policy tools. Similarly, the prominence of the start-up and market aggregation problems suggests that supply-side, rather than demand-side subsidies would more likely be effective. Therefore, the most relevant approach may be provision of grants to selected societies to aid in the conduct of technical translation and dissemination services.

Grants to non-profit societies could be structured in such a way as to constitute only a partial subsidy of the services provided. They could be conditional upon the society charging users a fee for service, to ensure that some sensitivity to market demand is taken into account in designing and operating the service. One "price" for public subsidy could be that the products of such services would be made available to all users, not only to members of the grantee organization. A grant program might allow for a great deal of experimentation with the format and nature of the services provided in order to learn what best meets user needs. Access to such products through computerized information banks, including the National Technical Information Service, could be required as a condition of receiving Federal funds. The selection of specific societies and technical areas of focus could depend in part on the initiative of the individual societies, which would be required to demonstrate the importance of the area, depth of user interest, and commitment of non-Federal funds as part of a proposal for Government funding. Evaluation of proposals could consider explicitly the importance of the technical area to the Nation, as well as the quality of the proposing institution and its operating plan and staff.

However, making such grants would raise several issues, in addition to the imposition of costs on the Federal budget. A mechanism would be needed to ensure the control of the quality of the products produced and to ensure that

whatever products are produced meet the needs of users in industry and Government, as well as academia. Finally, offering such grants to non-profit organizations might raise questions in some quarters about possible subsidy of competitors to private sector suppliers.

E. AUGMENTING PRIVATE SECTOR ACCESS ACTIVITIES

The market failures underlying the rationale for support of professional and technical society efforts discussed above apply even more to the efforts of the private, profit-making sector to build businesses around information access and dissemination.[31] However, the range of relevant policy instruments for assistance is not limited in this case to direct grants for the supply of information. Instead, both direct and indirect approaches, as well as both demand and supply subsidy remain relevant.

Tax incentives could be used to encourage the entry of firms into the market for dissemination of foreign technical information. However, two problems may arise. First, each effort must pass through a start-up phase in which it may have no net income to tax, and, if it is a new firm it may have no tax liability against which to offset tax credits. (Credit carry-forward provisions could help in this circumstance.) Second, it may prove to be difficult to administer a tax incentive to private businesses to increase the supply of foreign technical information because it may be difficult to write tax rules that clearly differentiate such activities from firms' related

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[31] Private firms in the United States are not finding ready markets for English translations of abstracts of Japanese technical articles. See, Clay Chandler, op cit. As an illustration of the difficulties encountered, a new service called "Japan Computer Technology and Applications Abstracts" ceased publication after offering only two issues in January and February 1987. Janet Macik, University Publications of America, personal communication, September 14, 1987.

research and development, marketing, and publishing activities. Furthermore, targeting a tax incentive to technical areas of highest national priority may not be feasible. As an alternative, it may be feasible to offer a subsidy on the demand side to users of foreign sources of technical information by, for example, providing tax incentives or direct grants to firms and/or universities that purchase "qualified" information products, such as journals, computerized information bases, or consulting services. Here too, however, administering such a policy may prove challenging. Either a demand or supply subsidy would raise issues of quality and appropriateness to user needs similar to those discussed above for subsidy of non-profit providers.

F. AUGMENTING ACCESS ON THE GROUND

Other countries, and especially Japan, are well known for their aggressive pursuit of scientific and technical information from other countries. Large numbers of foreign scientific and technical personnel visit the United States each year and report to their employers and colleagues regarding observations made here. Equivalent travel and reporting by American personnel is much more limited in all sectors: business, academia, and government laboratories.

In view of the traditional self-sufficient attitude of U.S. technical professionals and their industrial employers, the limited attention to foreign travel is understandable. In the United States, foreign travel is often viewed as a "junket" or vacation in disguise, rather than as an opportunity to study and to transfer technology from abroad. In some circles there is a prejudice against foreign travel for this reason. Market failure also plays a role: persons who travel overseas and pay the costs of that travel learn information that often finds its way to others who didn't help pay the travel bill. That is, there is a mismatch between those who pay and those who stand to benefit.

This mismatch flows from the lack of appropriability of the "property" represented by information. Within the market failure framework, this mismatch provides a rationale for socializing some of the costs of foreign travel and information access via government action or other cooperative means. This rationale is parallel to the one that underlies the socialization of some of the costs of doing basic and applied research via grants to universities and firms and the provision of tax incentives to firms for doing research and development.

A number of specific opportunities could be considered for subsidizing the costs of overseas travel and information access. (Enhancing the supply of travel by paying some portion of its costs seems to be much more feasible than subsidizing the demand for travel, for which there is no direct mode of implementation.) Grants could be made to individuals or organizations to pay part of the costs of foreign travel for learning about technical developments, conditional upon the traveler sharing his new knowledge via publication, speaking, and consulting. Travel periods could range from a few weeks to a year. Nearly total subsidy might be required for academic employees, whereas cost sharing could be entered into with industry (especially small business) or government laboratory employees. Industry could also be encouraged to involve its employees in foreign travel using tax incentives. Travelers for long periods of time could affiliate with foreign research institutes, universities, or industry, or in selected cases with overseas offices of U.S. science agencies, such as the National Science Foundation in Tokyo or the Office of Naval Research in London or Tokyo.

Travel for screening and acquiring information can only be effective if it is coupled to a mechanism for analyzing and disseminating the information to

potential users.[32] In part, such coupling will occur naturally through the participation of the erstwhile traveler in the technical community of which he is a part[33]. Some of the benefits of travel by private company employees would flow back to society if and as the new knowledge they obtain is put to work to create wealth, jobs, and tax revenues for society. In addition, however, it may be worthwhile to structure these functions, perhaps by requiring the traveler to publish a summary of his observations in a technical journal or in a specially edited "journal of trip reports" whose production could be separately subsidized. Subsidized travelers could also be required to deposit more lengthy reports of their observations in the National Technical Information Service for general distribution.

G. LANGUAGE TRAINING

In the long run, foreign language training is one of the more fundamental approaches to solving the problem of access to foreign scientific and technical information. Foreign language skills are needed not only for scientists and engineers, but also for the larger citizenry. As recently as two decades ago, to earn a doctorate in science or engineering a student had to demonstrate a reading knowledge of two foreign languages, whereas today many programs have

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[32] Paul Rubin, op cit.

[33] Secondary publication in the less-formal technical/professional press may be a highly cost-effective means of dissemination. For example, the JTECH program produced not only detailed technical reports, but also articles in the trade press. See, for example, Richard J. Seltzer, "Japan Aims for World Leadership in Advanced Polymers by 1990s," Chemical and Engineering News, November 17, 1986, pages 35-38; Trudy E. Bell, "Japan Reaches Beyond Silicon," IEEE Spectrum, October 1985, pages 46-52; and Anon., "Assessing Japan's Role in Telecommunications," IEEE Spectrum, June 1986, pages 47-52.

eliminated their language requirements completely.[34] The Government could help alleviate this problem by providing fellowships for students who are willing to study a foreign language as part of a graduate program.[35] (NSF has proposed a program of this type for FY88.) Federal funds could also support writing of specialized language training materials for scientists and engineers, whose interest in foreign languages is, for better or worse, likely to be more instrumental than cultural.[36]

However, language training is problematic and not a panacea. Unlike students in most foreign countries, where English is now the second language of choice, the choice of a foreign language to study is not clear for Americans. Should they study Japanese, the current language of choice for engineers, or should they study Spanish, the second most frequently spoken language in the United States and the one most likely to be useful both on the job and in daily life? Or should they study Chinese, the first language of more people in the

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[34] Fewer than 400 science and engineering students in the United States are now receiving Japanese language instruction, according to one survey. See, Samuel K. Coleman and Richard J. Samuels, "Applied Japanese Studies for Science and Engineering at American Universities," Engineering Education, January 1986, pages 206-210.

[35] Stanford University is cooperating with Kyoto University in Japan in two new programs for U.S. students. A Center for Technology and Innovation at Kyoto will make it possible for 30 Stanford science and engineering students to spend six months in Japan, half studying and half in industrial internships. A Program in Japanese Studies will host U.S. students with strong backgrounds in Japanese language and culture to spend two quarters at Kyoto doing further studies in these areas. The latter program will be open to students from other U.S. universities including Brown, Harvard, Princeton and Yale, as well as Stanford. See, "Stanford Branches Out," Science, January 2, 1987, page 26.

[36] At the present time, Federal funds are not available to assist in the preparation of technically-oriented Japanese language textbooks or dictionaries to assist translators of scientific and technical information from Japanese to English. Prof. R. Byron Bird, University of Wisconsin, Madison, personal communication, September 29, 1987. (See, E. Daub, R.B. Bird, and N. Inoue, Comprehending Technical Japanese, University of Wisconsin Press, 1975.) Also, Charles T. Owens, National Science Foundation, personal communication, October 9, 1987.

world than any other and perhaps the language most likely to emerge as newly important to science and engineering in the next few decades? Students committed to a career in international engineering face a further difficult choice problem: what is the probability that someone with their technical specialty and language specialization can find appropriate employment in the future? Furthermore, to remain usable for accessing foreign scientific and technical information, a foreign language must be exercised regularly, and most Americans have only rare needs for a foreign language. It is likely that foreign language competence and practice will remain a highly specialized niche for American engineers, and that those who choose this route face a career "dead end" -- there is no obvious ladder of advancement for an engineer who specializes in foreign languages and technology transfer. Educational subsidy might induce additional people to make this career choice.

H. FUNDING RESEARCH AND DEVELOPMENT ON MACHINE TRANSLATION

It is beyond the scope of this paper to discuss the pros and cons and state of the art of machine translation as a means of accessing foreign scientific and technical information. At best, however, this technology can only perform a portion of the tasks needed to ensure effective access. And, research on machine translation continues to disappoint those who initially envisioned translation as a straightforward problem of substitution of words and syntax.

Nevertheless, work is being done in this country and abroad to advance machine translation, or more modestly, "machine assisted translation" of Japanese into English (and vice versa). Direct Federal support for machine

aided translation in the United States has been limited for two decades.[37] The National Science Foundation is not supporting any research in this area at the present time.[38] The Air Force has supported some work in the area since 1985.[39] Japanese firms have been involved in machine translation of Japanese into English for some time, and several have marketed translation systems.[40] However, according to one expert, these have not been well-received in view of their low level of performance.[41]

Research and development on machine aided translation of foreign languages into English might be more generously supported than it has been. Support could be offered for both basic research in linguistics, language acquisition, and artificial intelligence, and applied research and development of prototype translation systems.

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[37] Winfred Lehman, Director, Linguistics Research Center, University of Texas, Austin, personal communication, September 14, 1987.

[38] Fran Kartunnen, Program Manager for Linguistics, National Science Foundation, personal communication, September 14, 1987.

[39] Tamami Kusuda, op cit.

[40] Japanese-to-English systems are now being sold by Fujitsu, Hitachi, Sanyo, Oki, and NEC; and additional firms have been doing research in the area, according to a compilation prepared for the Machine Translation Summit conference held in late September, 1987. Sabina G. Javits, Office of Japanese Scientific and Technical Literature, personal communication, October 6, 1987.

[41] Winfred Lehman, op cit.

V. ACCESS-ENHANCING POLICY OPTIONS AND THEIR COSTS

A. A NOTE ON THE OPTIMAL SCALE OF EFFORT

There is perhaps no way to estimate the value that might be gained from accessing foreign scientific and technical information, nor can one use such a value alone to estimate how much should be spent on access efforts. In fact, an estimate of the appropriate level of spending would depend on estimates of where the marginal costs of access equaled the marginal benefits, and such estimates are not likely to be forthcoming.[42] However, it might not be unreasonable to argue that between one and ten percent of a research and development budget could be profitably devoted to accessing foreign technical information. At the national level, this would translate into approximately one to ten billion dollars per year for access, when compared with total national R&D expenditures of over $125 billion per year[43]. By contrast,

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[42] One barrier to making such estimates is that in dealing with commodities for which important market failures exist, the empirical problems of inferring the "true" values of goods the market undervalues can be overwhelming. Furthermore, the socially optimal level of public spending for foreign information access depends on both private and public benefits, as well as private expenditures, and none of these quantities is likely to be measurable, even in principle. Finally, the socially optimal level also is influenced by considerations of equity, as well as economic optimality, in regards to such matters as access by small as well as large firms.

[43] Division of Science Resources Studies, National Science Foundation, "Science and Technology Data Book-1987" (NSF86-311), Washington, D.C., 1986.

current Federal expenditures for access to foreign technical information total at most a few million dollars annually.[44]

B. COST ESTIMATES FOR PROGRAM ALTERNATIVES

In order to provide some insight into the kinds of policies and programs that might be considered to facilitate U.S. access to Japanese scientific and technical information, policy proposals were compiled from the sources listed in footnotes 1, 2, and 4, and additional alternatives were developed by CRS. Rough estimates of the order of magnitude of the costs of these policy alternatives were also developed. These are intended to be indicative only; actual costs would depend on the scale and details of each program. While these proposals are targeted specifically on information from Japan, they may be applicable to other areas of the world as well, and, in many instances, it may be more useful to think in terms of the industrial world, rather than Japan alone. The programs, listed in no particular order, are as follows.

- **Subscription to 10,000 Japanese technical journals**

A national institution, such as the National Technical Information Service, the National Science Foundation, or the Library of Congress, could subscribe to the approximately 10,000 scientific and technical journals originating in Japan, and make them available to the public.[45] If it is assumed that the average price of these journals is $100 per year[46], the total cost would be about $1 million per year, exclusive of archiving costs.

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[44] National Science Foundation, April 1985, op cit.

[45] The Library of Congress currently subscribes to approximately 2,200 Japanese scientific and technical journals. L.C. Bruce, Science and Technology Division, Library of Congress, personal communication, September 28, 1987.

[46] Donald W. King, et al., op cit., page 27, report that the average price of a journal in the field of energy was $85 in 1982.

- Translation of 10,000 Japanese technical journals into English

Some have proposed wholesale translation of Japanese technical journals into English on a routine basis. Assuming that one annual volume of the average journal consists of 400 pages of 200 words per page, and that translation costs 10 cents per word, it would cost $80 million per year to translate 10,000 journals into English.[47] A thousand or more full-time equivalent translators would be needed, a number that far exceeds the available supply at any price. This approach would be not only expensive but inefficient. To be used effectively, translation resources would have to be more sharply targeted than the wholesale approach would entail.

- Subsidy of short-term travel to Japan by scientists and engineers

One of the most effective means of keeping abreast with developments in science and technology is to visit the laboratories where the work is being done and to attend the meetings at which the work is discussed. In view of past patterns of such visits by Japanese researchers to the United States, the subsidy of 1,000 such visits per year at $10,000 per trip would cost $10 million per year. (NSF has proposed a much smaller program of this type for FY88.)

- Comprehensive journal of technical trip reports

A Federal agency, such as the National Science Foundation or the National Bureau of Standards, could support and oversee the production of a "journal of technical trip reports," which would be based on summary reports of trips taken

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[47] These per unit cost estimates, like all others in this section, are not authoritative, but indicative. By comparison, E. Bruce Peters, op cit., page 37, gives a cost of $200 to 300 to translate a typical technical article. The Japan Computer Technology and Applications Abstracts journal listed prices for full translation equivalent to about $110 per page of Japanese original.

to such nations as Japan by U.S. scientists and engineers.[48] These reports would emphasize the traveler's observations concerning the state of the art of R&D in Japan in his field, discuss the leading researchers and institutions, and identify interesting new developments. In order to maximize the utility of such reporting, the sponsoring agency would have to set guidelines for their content and oversee their quality, and this might entail training and guidance of potential travelers.

For example, the sponsoring agency could support, in whole or in part, the travel of two U.S. engineers each year in each of 20 technical specialty areas to each of five locations around the world. (NSF has proposed to support a limited amount of such travel for FY88) In return, the travelers would be required to submit comprehensive reports of their observations for distribution by the National Technical Information Service and to prepare summary reports for publication and wide dissemination in a monthly or bimonthly journal. At a cost per trip of $10,000 for 200 person-trips each year, the travel portion of this program might cost $2 million. (Only one-fifth of this amount might be directed toward Japan, with the remainder going toward other nations.) The editing and production of 10 issues per year of a journal might cost and additional $300,000 per year. Reproduction and dissemination costs for the detailed reports and the summary journal could be met from cost recovery from subscribers. Some or all of the publication activity could be contracted out to private organizations, and policy direction, including selection of countries, fields, and participants, could remain with the responsible agency.

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[48] Administrative travel reports required under current NSF foreign research grants are not publicly distributed. Henry Hertzfeld, consultant, personal communication, September 14, 1987. These reports typically include only one or two paragraphs regarding the traveler's own research overseas. Charles T. Owens, National Science Foundation, personal communication, October 9, 1987.

- Graduate fellowships for study of Japanese and science or engineering

In order to encourage students of science and engineering to study Japanese and to learn about Japanese scientific and technical activities, a special fellowship fund might be created as an addition to the graduate fellowship programs of the National Science Foundation. Assuming a sustained commitment to language training, as well as a period of study in Japan in the course of a U.S. doctoral program, support for a five-year period of study would probably be needed. Support for each student might cost $12,000 per year in the United States, and $15,000 for a year overseas. Thus, to support 100 new fellows each year (500 in place each year at full program implementation) for five years of graduate school, including one year in Japan, might cost $6.3 million in direct aid. In addition to direct fellowship aid costs, it might be necessary to establish special language training materials development programs and technical Japanese courses around the country. Support of such programs at 20 major universities might cost $100,000 per year each, or $2 million per year.

- Research fellowships for study in Japan

While short-term visits to Japan can introduce an American scientist or engineer to the broad sweep of R&D in his specialty, developing a secure understanding of the activities in a field, including some facility in translating and understanding work in the area, may be more effectively carried out over a period of one or two years. Recent changes in Japanese law have made it more feasible for foreigners to take up research posts in universities, and a number of Japanese research centers have stated their willingness to host American researchers.

An agency such as the National Science Foundation or the Department of Commerce might sponsor research fellowships for work in Japan by scientists and engineers from U.S. industry, academia, or government laboratories. Costs

might be shared with industrial employees, while academics and government employees might need full cost subsidy. Language training would also need to be a part of the pre-departure preparation by fellows.

Considering travel and stipend, as well as language training might lead to a cost of approximately $75,000 per year per fellow. However, since some fellows might participate on a cost shared basis, a average of $50,000 per year per fellow might be used as the basis for estimation. Thus, a program involving 100 fellows at any time would cost $5 million per year.

- Maintenance of a permanent science and engineering mission in Japan

Both the National Science Foundation and the Office of Naval Research currently maintain offices in Japan to track scientific and engineering developments there. In addition, the Japanese Technical Literature Act of 1986 authorizes the Department of Commerce to establish such an office. This proposal would upgrade the size and scope of these staffs to enable them to track more areas continuously and in greater depth. Staff could be detailed from technical agencies or be visitors from universities and the private sector on loan to the agency in charge. If the staff consisted of 20 full-time technical personnel at a cost of $225,000 each for salaries, travel, clerical and administrative support, and other operating costs, a total cost of $4.5 million per year might be incurred.

- Subsidy of translation/abstracting/dissemination journals

As noted above, a number of the technical and professional associations have begun to disseminate English abstracts and/or interpretive articles on the state of science and technology in Japan in specific fields. Commercial vendors have also begun such efforts, typically covering a broader range of literature than the non-profit groups. These efforts face high start-up costs and considerable skepticism about their utility in the technical community.

Most are being offered on an experimental basis to test the market and to determine what kind of service might best meet user needs. Congress could consider offering relatively limited Federal assistance to, for example, twenty non-profit groups and five commercial services. If subsidy to the former costs $100,000 per year each, and to the latter $300,000 per year each, the total annual cost of such a program would be $3.5 million.

- Tax incentives for corporate access activities

Some have suggested that the most effective means of accessing Japanese technical developments is for individual firms to do the necessary work themselves. However, the considerations of market failure discussed above suggest that, on average, firms will underinvest in such activity as compared with the economically optimal level of investment. By analogy to tax incentives for research and development, tax incentives could encourage access by firms, while maximizing their flexibility to use whatever means best meets their needs. One such incentive would be to offer a fixed percentage credit against tax due for such qualifying expenditures as maintaining technology transfer agents on site in Japan, fees for consultants in Japanese technology, subscriptions to qualifying journals, translation expenses, and employee language training. While estimating the impact of such a credit on tax revenues is largely a matter of conjecture in view of the lack of prior experience with such incentives, a credit of 50% of qualifying expenditures might lead to foregone tax revenues of $150,000 per year for each of 200 large firms and $20,000 per year for each of 1,000 small firms, for a total revenue loss of $50 million per year.

- Federal awareness, education, and training programs

In order to help stimulate interest in and the demand for Japanese technical information, a Federal agency such as the National Technical

Information Service or other responsible body might offer, or support, awareness, education, and training programs to help industrial personnel understand how to access and use foreign scientific and technical information. (NTIS and the Office of Japanese Scientific and Technical Literature have begun a modest effort of this type.) Typical programs might include six regional training conferences per year at a cost of $50,000 each, and distribution of 100,000 brochures by mail at $0.50 each (plus preparation costs of one person-year of effort) for a total cost of about $400,000 per year.

- Sponsorship of research on machine-aided translation

If Congress were to decide to sponsor additional research on machine aided translation of Japanese into English, a reasonable level of effort might include ten grants or contracts per year to universities, non-profit organizations, and companies for research and development on fundamental linguistics, translation algorithms, and devices. If these grants and contracts were to average $1 million per year, a total program would cost approximately $10 million per year.

- Extension of the JTECH program to a range of key fields

The Japanese technology evaluation (JTECH) program, which has been viewed as experimental up to now, could be made permanent and extended to cover a number of fields. For example, if 20 studies were carried out per year at a cost of $100,000 each,[49] total program cost would be about $2 million per year.

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[49] The first five studies in the JTECH program had an average cost of approximately $135,000 each. The estimate of $100,000 used here is based on the presumption that a non-experimental program could be carried out at somewhat less cost per study.

C. ESTIMATED TOTAL COSTS FOR ACCESS TO JAPANESE TECHNICAL INFORMATION

Using the above cost estimates for program elements as a basis, one can estimate the costs of one or more broad Federal programs for accessing Japanese technical information. By far the most expensive option would be comprehensive translation of large numbers of Japanese technical journals into English, which was estimated above to cost on the order of $80 million per year, and which might cost several times that amount if the estimate of the "size" of that literature is low.

The second most expensive program according to the above estimates would be a tax incentive to private firms to encourage them to spend their own funds for access to Japanese technical information. This estimate is highly uncertain, however, since no information exists on the number of firms that might participate or on how much they might spend on such activities. (The estimate of $50 million in lost tax revenue offered above is equivalent to somewhat less than one percent of the expenditures of their own funds for research and development by firms in the United States.) The availability of such a tax incentive would create opportunities for private entrepreneurs in the translation and consulting fields, and enhanced competition among them might reduce the costs of such activities for each user firm.

In comparison, the other program options discussed above are less expensive. For example, combining foreign language upgrading, support for special graduate fellowships, subsidy of overseas travel, and production of a "journal of trip reports" taken together might cost a total of $25.1 million per year.[50] By comparison, Federal obligations for basic research alone are

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[50] NSF's FY88 proposals to assist in foreign technical information access requested a total budget of approximately $1.3 million. Charles T. Owens, National Science Foundation, personal communication, October 9, 1987.

estimated to total approximately $8.4 billion in 1987[51]. Thus, these programs would cost the equivalent of about 0.3 percent of Federal basic research support, or about 0.04 percent of total Federal funds for all R&D of over $60 billion in 1987.

It is difficult to quantify the benefits to science and engineering of this package of programs to improve access to Japanese scientific and technical information. However, if the availability of such information as a consequence of these programs were to result in obviating the need to carry out as little as 0.15 percent of total U.S. basic research (now costing a total of $15 billion per year[52]) or 0.02 percent of total U.S. research and development (now costing over $125 billion per year[53]) it would be cost-effective for the Nation.

The benefits of access to foreign scientific and technical information to the U.S. are not limited to the avoided costs of unnecessary R&D. Perhaps more significant, but also even more difficult to quantify, the benefits include a potentially more competitive industrial base for the Nation. For example, the U.S. (negative) balance of trade with Japan in "high-technology" goods in 1984 was nearly $16 billion[54]. While this balance is due to many factors other than the relative technological capabilities of the two nations, if improved access to Japanese technical information that costs $23.6 million per year were to

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[51] Science Resources Studies, op cit.

[52] ibid.

[53] ibid.

[54] Vicky Hatter, "East Asian Countries Play Key Role in Eroding U.S. High-Tech Trade Surplus," Business America, September 2, 1985, pages 6-9.

reduce the high-technology balance of trade with Japan by only 0.1 percent, it would probably be judged "cost-effective" in these terms.[55]

These comparisons suggest that an investment of Federal funds of the order of magnitude discussed above in improving U.S. access to Japanese technical literature is likely to be cost effective. At the same time, real costs would be incurred, either in terms of additional Federal expenditures or the displacement of an equivalent amount of current R&D funding. Furthermore, since there remains substantial uncertainty about the demand for and utilization of scientific and technical information from abroad, Congress may wish to periodically monitor and reassess whatever commitment it might choose to make to improving access to Japanese technical information.

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[55] Economic adjustment processes operating elsewhere in the economy would offset a part of this benefit, so this comparison should be taken only as indicative and not precise.